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Studies on innocent praecordial vibratory murmurs in children

II: Systolic time intervals and pulse wave transmission times in children with an innocent praecordial vibratory murmur

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Investigations were done on 15 children (aged between 2·8 and 10·0 years) with an innocent praecordial vibratory murmur, conforming to the criteria of Harris and Friedman (1952). Left ventricular ejection time and pre-ejection period were calculated from electrocardiogram, phonocardiogram, and external carotid pulse wave recordings obtained in a supine position at rest. Pulse wave transmission times, derived from external arterial pulsation tracings, were calculated for extremities and central aorta. The findings in these 15 subjects were compared with 15 length and age-matched normal children without a murmur.

The mean values for heart rate, left ventricular ejection time, and pulse wave transmission time in both groups did not differ significantly, neither did the group with innocent praecordial vibratory murmur differ from the total group of 52 normal children from which the 15 were selected. The mean pre-ejection period of the group with innocent praecordial vibratory murmur, however, was significantly shorter than the total group of normal children ($P<0·01$). When compared to the group of matched controls this difference was significant at the level of $P=0·05$. The results are discussed in relation to estimated systolic peak flow values through the aortic ostium and other implications such as the origin of the praecordial vibratory murmur.

The shorter pre-ejection period in the group with innocent praecordial vibratory murmur may be attributed to a higher contractility of the left ventricular myocardium, resulting in a higher aortic peak flow.

The same left ventricular ejection times for both groups make it implausible that aortic stenosis is a cause of the systolic murmur.

The origin of the innocent praecordial vibratory murmur as described by Harris and Friedman (1952), Paulin and Mannheimer (1957), Rushmer (1955), and McKusick (1958), is still a matter of debate.

McKusick (1958) postulates the vibration of a solid structure such as the ventricular wall or a chorda tendinea in order to explain the vibratory quality of the murmur. Most authors however do not commit themselves on the subject.

In 1959, Bruns published his studies on the causes of murmurs in the cardiovascular system. His theory, based on the principle of the aeolian harp, leaves room for the possible generation of regular (sinus wave) vibrations in the blood stream.

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On the assumption that the innocent praecordial vibratory murmur in children originates in the blood stream, an attempt was made to obtain information concerning haemodynamics in these children, using non-invasive techniques.

In order to create a valid basis of comparison, a control group of 85 subjects aged 1 to 21 years was investigated first. The results of this last study are published separately (van der Hoeven, de Monchy, and Beneken, 1973).

Subjects and methods

The innocent praecordial vibratory murmur group consisted of children referred to the outpatient department for cardiac examination because of an accidentally discovered cardiac murmur. Consecutive subjects from this group were investigated without any further selection. They were free of complaints and had no history of rheumatic fever or serious infectious diseases. Careful physical examination did not reveal any pathology relating to the cardiovascular system and on auscultation the murmur conformed to the criteria of Harris and Friedman (1952) for the innocent praecordial vibratory murmur, grade 2, early systolic with vibratory quality, transmitted over the entire praecordium, with maximum intensity at the lower left sternal border or near the apex. Additional examination comprised electrocardiogram, *x*-ray of the thorax, and phonocardiogram, which confirmed the diagnosis: spindle-shaped, early systolic murmur ending at two-thirds of systole, predominantly present in the middle frequency range with regular sinus wave pattern and maximum amplitude at the left lower sternal border; normal heart sounds; normal pulsation tracings (apex cardiogram, carotid and femoral artery pulsations, jugular vein tracing).

From 15 children pulsation tracings were obtained under the same conditions and by the same investigators as mentioned in a previous study, reporting the findings in a group of 85 normal children without a murmur (van der Hoeven *et al.*, 1973). An example of one child with an innocent murmur is given in Fig. 1.

The age range of the children with a murmur varied between 2 and 10 years. Body height and weight fell within normal limits for age, compared to the general population.

Each child in the group was paired with one selected from the group of normal children on the basis of nearest body height. This control group of 15 children conformed within 2 SEM to the height-age regression line of the total normal group of 85 children (Fig. 2 and Table 1).

Values for the pre-ejection period, left ventricular ejection time, and pulse wave transmission times in the central aorta and the extremities were measured in the same way and with the same apparatus as already described for the group of normal children (Part I of this study). The statistical significance of the various parameters was tested by covariance analysis, Student's t test and regression analysis according to the methods of Snedecor (1967).

Results

Systolic time intervals

The results of the measurements are given in Table 1. When tested with Student's t test the mean left ventricular ejection time of the children with an innocent praecordial vibratory murmur did not differ significantly from the values obtained in a group of 52 normal children of the same age published in Part I (van der Hoeven *et al.*, 1973). The group of 15 carefully matched controls, chosen from this group of 52 normal children, also showed no difference in mean left ventricular ejection time (Fig. 3). Mean pre-ejection period in the group of 15 children with an innocent vibratory murmur was significantly shorter, as tested with the same Student's t test, when compared to the total group of 52 normal children (this difference is significant at the 0·01 level). Compared to the group of matched controls, this difference is still significant at the 0·05 level (Fig. 4).

This lower confidence level is caused by the relatively small number of subjects in both groups, but this is more than compensated for by the fact that both groups are rigorously identical in all measurable aspects, which gives more weight to the conclusions drawn by the Student's t test.

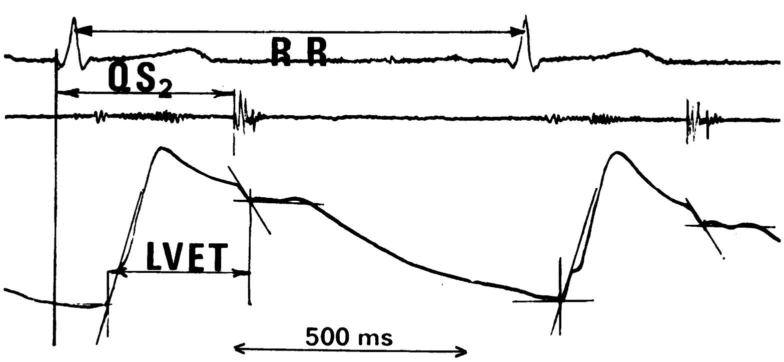

FIG. 1 *Reproduction of tracings recorded from subject No. 8 (innocent praecordial murmur group, Table 1). From top to bottom: Electrocardiogram lead II, phonocardiogram medium frequency range (70 Hz), external carotid artery tracing. PEP is calculated from QS_2 and LVET.*

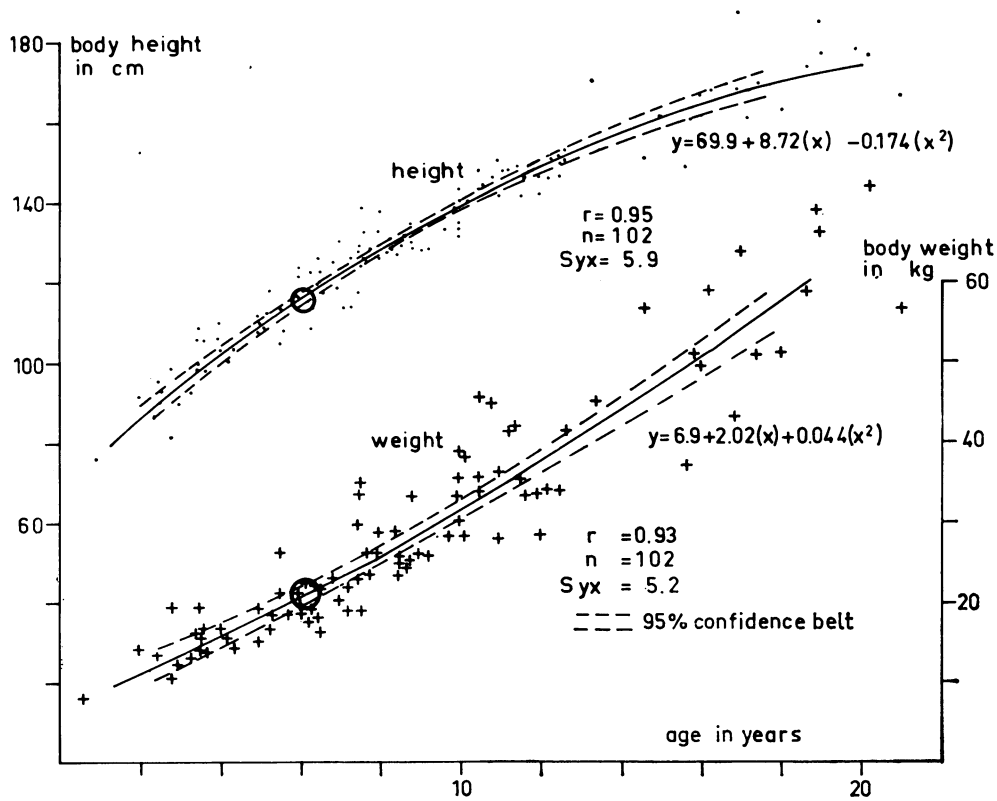

FIG. 2 *Mean body height and weight of the control group of 15 children compared to the group of normal children from which they were selected. Mean values of 15 children are indicated by open circles.*

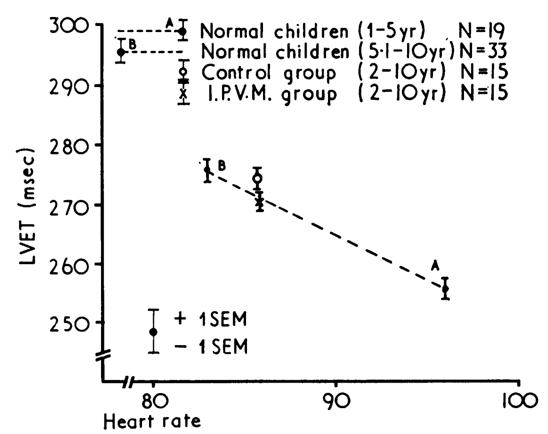

FIG. 3 *Mean left ventricular ejection time in children with a praecordial vibratory murmur compared to a group of matched controls and normals. SEM, standard error of mean.*

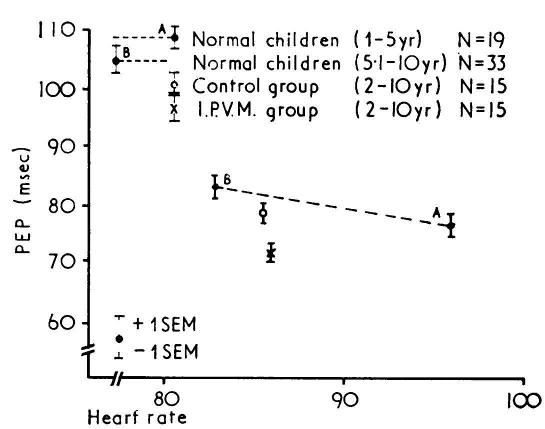

FIG. 4 *Mean pre-ejection period in children with a praecordial vibratory murmur compared to a group of matched controls and normals. SEM, standard error of mean.*

TABLE 1 *Values for left ventricular ejection time (LVET) and pre-ejection period (PEP) with means of children with a praecordial vibratory murmur and matched controls*

Subject No.	*Sex*	*Length (cm)*	*Age (yr)*	*Weight (kg)*	*Heart rate*	*LVET (msec)*	*PEP (msec)*
Control Group							
1	M	127	7·5	23·2	87	248	95
2	M	106	3·6	17·1	83	286	75
3	M	114	6·3	19·2	70	296	91
4	F	114	5·5	21·7	98	281	82
5	M	129	9·2	26·0	107	255	58
6	F	125	6·8	23·8	66	308	82
7	F	134	10·0	27·5	60	302	96
8	M	127	6·5	22·5	100	262	76
9	F	105	5·5	18·0	88	275	69
10	M	119	7·0	20·5	75	283	84
11	M	109	3·5	19·6	104	257	85
12	F	99	2·8	15·8	76	275	85
13	M	122	6·0	21·4	70	296	75
14	F	101	4·2	15·6	90	254	70
15	M	103	4·0	17·2	111	240	72
Mean		115·6	5·9	20·6	85·6	274·5	79·6
SEM						2·8	3·0
Innocent praecordial vibratory murmur group							
1	M	128	9·0	26·4	78	275	46
2	M	106	3·5	15·9	101	263	73
3	M	116	6·0	20·0	87	272	77
4	M	114	6·0	19·1	99	256	81
5	M	129	8·4	29·6	87	270	85
6	F	123	6·3	22·7	78	233	72
7	M	134	9·7	28·1	80	304	66
8	M	130	8·5	26·0	92	254	49
9	M	105	5·0	16·5	84	295	76
10	M	117	7·5	22·0	86	272	78
11	M	111	5·9	21·4	80	265	83
12	M	98	3·0	15·2	80	273	74
13	F	120	6·0	22·3	69	291	84
14	F	101	3·9	16·3	76	291	70
15	F	106	3·9	17·0	110	249	71
Mean		115·8	6·1	21·2	85·8	270·8	72·3
SEM						3·3	3·1

SEM, standard error of mean.
Note: Equal numbers in both groups are matched for height.

Pulse wave transmission times

No statistically significant difference in pulse wave transmission time was found between the children with a murmur and the control group (Table 2), if the difference in pre-ejection period is taken into account. Blood pressure readings in both groups conformed to normal standards for age.

Discussion

Interest in left ventricular function in children with this murmur was aroused by experimental data pointing to its possible left ventricular origin (de Monchy, 1966a, b). The murmur was shown to vary consistently in amplitude with variations in the cardiac output, in the same manner as ejection murmurs due to semilunar valve stenoses. Valsalva manoeuvre experiments suggested the left side of the heart as its probable site of origin. In recent years, intracardiac phonocardiography in children with a praecordial vibratory murmur revealed a murmur transmitted to the right side of the heart, presumably originating in the left ventricle (Wennevold, 1967).

Suggestive as these findings may be, several questions remain. Why are the murmurs only found in children and never in adults? Is there any connexion between the murmur and aortic valve stenosis, how-

TABLE 2 *Pulse wave transmission times (PWTT) in msec*

	Wrist (msec)	*2 SEM (msec)*	*Groin (msec)*	*2 SEM (msec)*	*Instep (msec)*	*2 SEM (msec)*
Praecordial vibration	135·2	9·3	157·6	10·7	239·8	23·0
Control	141·4	10·5	160·4	11·9	252·5	23·2

SEM, standard error of mean.
For discussion see text.

ever slight? What does the presence of the murmur mean in terms of left ventricular function? Does the arterial system play a role in its occurrence?

Systolic time intervals

From the present study it appears that children with a praecordial vibratory murmur have a significantly shorter pre-ejection period than comparable subjects without this murmur which is sometimes used as an indication of a higher contractility of the myocardium (Weissler, Harris, and Schoenfeld, 1969; Montoye *et al.*, 1970; McConahay, Martin, and Cheitlin, 1972). The fact that no difference in diastolic blood pressure was found between the two groups also points to the myocardium. On the other hand, left ventricular ejection time did not differ significantly from the control children, which means that the aortic valves of the children with a murmur did not obstruct the blood flow in a measurable way. Robinson (1963) showed that left ventricular ejection time is prolonged in cases of aortic stenosis. In our group of 15 children with a praecordial vibratory murmur, if anything left ventricular ejection time tended to be shorter.

These findings suggest a higher peak velocity of the blood across the aortic valves during ejection in subjects with a praecordial vibratory murmur than in children without this murmur.

In an analogue computer model (Beneken and de Wit, 1967; van der Hoeven, 1970) of the arterial circulation in children peak blood flow velocities were calculated for children of different ages (Fig. 5), incorporating standard adult values for myocardial contractility and left ventricular ejection time and using published data for calculation of age-dependent parameters such as heart rate, stroke volume, cross-sectional area of aortic valve orifice, aortic impedance, etc.

The results show a distinctly higher peak flow in children than in adults, which difference would have been even more pronounced if the lower values for pre-ejection period in children and recent data on left ventricular ejection time and the elasticity of the aortic wall had been available at the time. This could be the reason why the praecordial vibratory murmur is only found in children and disappears after puberty.

Pulse wave transmission times

As concluded from pulse wave transmission time values, no difference was found in the elastic properties of the arterial wall between children with and

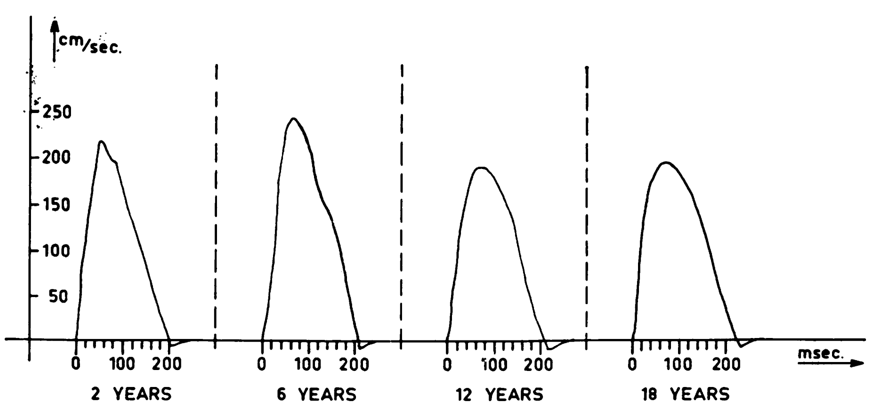

FIG. 5 *Mean peak blood flow velocities in children of different ages, as calculated from analogue computer model.*

without a praecordial vibratory murmur. Also, as already mentioned, blood pressure readings between the two groups did not differ significantly. This means that no difference in windkessel-function of the aorta can be assumed in explaining the presence of a praecordial vibratory murmur, which leaves left ventricular myocardial function as the most probable basic origin.

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Errata

'QT interval in right and left bundle-branch block' by S. Talbot, volume 35, p. 288 and 289.

(i) The last line of the summary should read 'by subtracting 0·02 sec less from the actual QTc'

(ii) First row, second column of the Table (mean QT in left bundle-branch block) should be 0·422 (SD 0·048).